FOOD AND FEEDING HABITS OF INDIAN BARBETS, *MEGALAIMA* SPP.[1]

HAFIZ S.A. YAHYA[2]

(*With three text-figures*)

Key words: Barbets, congeneric, sympatric, food, feeding method, ecological isolation, coexistence, conservation.

A comparative study on the ecology and biology of Indian barbets (*Megalaima* spp.) was carried out between 1977 and 1980 in different parts of the country. *Megalaima viridis* and *M. rubricapilla malabarica* were studied more intensively at Thekkady (Kerala), while *M. virens, M. zeylanica, M. lineata, M. asiatica, M. franklinii* and *M. haemacephala* were studied at other places. The findings on the feeding behaviour of the barbets are discussed in this paper. Data on food items, fruiting seasons, abundance of fruiting trees, feeding method and extent of ecological isolation in food habits of coexisting species are discussed. The barbets are predominantly frugivorous, but during the breeding season all species feed their young with insects. Among the congeneric sympatric *M. viridis* and *M. rubricapilla* at Thekkady, the former was found to be more insectivorous, helping considerably in checking the deadly teak defoliator *Hyblaea puera*. Contrary to reports of *M. zeylanica* and *M. viridis* being minor pests on coffee, they were found to be quite helpful to coffee plants in picking up the coffee stem borer, *Xylotrechus quadripes*. Barbets also help in seed dispersal and pollination of scores of trees, and thus play an important role in maintaining the rich biodiversity of the country, and they deserve conservation priorities.

INTRODUCTION

The name barbet is derived from the French *Barbu* (=bearded) which is suggested by the presence of nasal and rictal bristles. They are closely related to Old World honeyguides (Indicatoridae) and the New World puff birds (Bucconidae). The barbet family Capitonidae has a pantropical distribution. Ripley (1961) reported 10 species from the Indian subcontinent under the single genus *Megalaima*.

According to Simmons (1970), food supply plays an important role in determining the breeding biology, dispersion pattern and social system of a species through natural selection. In this paper, apart from mentioning the main food items, fruiting seasons and abundance of fruiting trees at Thekkady, the food and feeding methods of coexisting *M. viridis* and *M. rubricapilla* are described to ascertain the extent of isolation in food habits. Food habits of *M. zeylanica* and *M. haemacephala* are also discussed briefly. The impact of food habits of *M. viridis* on coffee plantations was assessed and has been published elsewhere (Yahya 1982). Barbets do not drink water regularly, but they were often recorded drinking water and bathing from the rain filled natural tree holes. Drinking and bathing behaviour have been described elsewhere (Yahya 1991).

The study was carried out mainly in the Periyar Tiger Reserve (9° 30' N lat. and 77° 10' E long.) Kerala, consisting of evergreen, semi-evergreen, shola, moist-deciduous and savanna forests. Details of the study area have been published earlier (Ali 1935, Yahya 1980, 1988, 1989, Vijayan 1984, and Robertson and Jackson 1992). Comparative studies were made at several other locations.

[1]Accepted June, 1999
[2]Centre of Wildlife & Ornithology,
Aligarh Muslim University,
Aligarh 202 002, Uttar Pradesh, India.

On reconnaissance, it was found that moist deciduous forest was favoured most by the barbets (Yahya 1989). Therefore, Thekkady – a small area of moist deciduous forest, 3 km in length and an average of 0.5 km wide, was selected for intensive study. A road of about 4 km passes through the middle of the forest connecting the reserve to the nearby town Kumily. There are several buildings in this area, besides a picnic spot and a caravan park.

Methods

Barbets were observed in their natural condition for about three years to study various aspects of their ecology and biology. Data was collected on food and feeding habits between April 1978 and April 1979.

Each day was divided into three 4-hour shifts; 0600 to 1000 hrs, 1000 to 1400 hrs and 1400 to 1800 hrs. Observations were made on alternate shifts. On two days in each month, barbets were followed for the whole day. Fruiting of trees was recorded each month by trekking through different routes in the study area at least every fifth day.

The data collected included food items, heights at which the birds fed, number of birds feeding at that time and any antagonistic behaviour. Barbets are mostly arboreal birds and only on five occasions did I note *M. viridis* searching for food on the ground. Hence, the vertical height distribution of feeding zone was divided into three broad levels: Primary level 1 to 4 m, Secondary level 4 to 8 m and Tertiary level above 8 m. In the beginning, I tried to distinguish different canopies at which the birds fed, but this was not done later as both species were found exploiting the canopy equally.

The total numbers of each species of barbet recorded feeding on different fruiting trees and hunting insects were considered during the final analysis. As barbets hunt in the brighter hours of the day and in exposed areas, it was possible to identify such prey as cicadas, leafhoppers, ants, termites, butterflies, spiders, beetles and caterpillars. But barbets were seen to be primarily frugivores, and easy to observe visually, therefore no specimen was collected for stomach analysis. The data gathered from April 1978 to April 1979 are analysed here. During this period, a total of 3,346 *M. viridis* and 1,889 *M. rubricapilla* were recorded feeding.

Fruiting season and relative abundance of fruit trees in the intensive study area

Fruiting/flowering seasons of the principal trees/shrubs on which barbets were found feeding/sipping and relative abundance of fruiting trees in the intensive study area are shown in Tables 1 and 2 respectively.

Table 1
RELATIVE ABUNDANCE OF DIFFERENT SPECIES OF FRUITING/FLOWERING TREES VISITED BY BARBETS FOR FOOD IN THE STUDY AREA

(3 km x ½ km)

Plant species	Relative abundance			
	<5	5 to 10	10 to 15	>15
Actinodaphne hookeri				x
Bischofia javanica	x			
Bridelia retusa		x		
Bombax ceiba			x	
Careya arborea	x			
Erythrina sp.				x
Eucalyptus sp.				x
Evodea lunuankenda				x
Ficus gibbosa		x		
F. infectoria	x			
F. insignis	x			
F. mysorensis		x		
F. retusa		x		
F. tsiela				x
Grewia tiliaefolia				x
Lantana camara				x
Leea indica				x
Machilus macrantha			x	
Macaranga sp.				x
Olea dioica			x	
Santalum album				x
Scolopia crenata		x		
Solanum indicum				x
Spathodea campanulata			x	
Syzygium cumini		x		
Ziziphus sp.	x			

TABLE 2
FRUITING/FLOWERING SEASONS* OF PRINCIPAL TREES AND SHRUBS ON WHICH BARBETS FEED

Plant species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Oct	Nov	Dec
Actinodaphne hookeri				x	x	x	x				
Bischofia javanica	x										x
Bridelia retusa								x	x	x	
Bombax ceiba	x	x	x							x	x
Careya arborea			x	x							
Erythrina sp.	x							x	x	x	x
Eucalyptus sp.							x	x	x	x	
Evodea lunuankenda	x									x	x
Ficus gibbosa	x	x	x	x						x	x
F. infectoria	x									x	x
F. insignis							x			x	x
F. mysorensis	x	x	x			x	x	x	x	x	x
F. retusa	x	x	x	x	x	x		x	x	x	x
F. tsiela	x	x	x	x	x	x	x	x	x	x	x
Grewia tiliaefolia					x	x	x	x			
Lantana camara	x	x	x	x	x	x	x	x	x	x	x
Leea indica					x	x	x	x	x	x	x
Machilus macrantha		x	x	x							
Macaranga sp.		x	x	x	x					x	x
Olea dioica				x	x						
Santalum album				x	x				x		
Scolopia crenata				x	x						
Solanum indicum	x	x	x	x	x	x	x	x	x	x	x	x
Spathodea campanulata						x	x	x	x	x	
Syzygium cumini			x	x							

*As recorded between April 1978 to July 1979; no data for September 1978.

Almost all the trees except some *Ficus* fruit annually at Thekkady. Though the fruiting period varies from species to species and at times from one individual to another, there appear to be two peak periods of fruiting, April-June and November-December. However, during April-June 1979, comparatively few species of trees were recorded fruiting. This could be due to lower rainfall in the previous year, as the fruiting period of the same tree may vary from year to year due to rainfall and other climatic factors.

During April-June *Actinodaphne hookeri, Ficus gibbosa, F. tsiela, Grewia tiliaefolia, Machilus macrantha, Macaranga* sp., *Olea dioica, Santalum album, Scolopia crenata* and *Syzygium cumini* were the main fruiting trees.

During November-December, different species of *Ficus* were the main fruiting trees. Some other tree species also start flowering. From the flowers of *Erythrina indica, Bombax ceiba* and *Spathodea* sp., only *M. viridis* was seen sipping nectar. Among these, *Erythrina* flowers for an extended period of 5 months, mainly October to February, *Bombax* flowers from November to February and *Spathodea* mainly during June to August, though some trees were found flowering as late as November. *Bischofia javanica* fruits from November to January, whereas, *Bridelia retusa* fruits from August to November.

Fruits of *Lantana camara* and *Solanum indicum* comprise the regular food of *M. viridis*. These plants fruit almost throughout the year. *Leea indica,* on which only *M. viridis* feeds, fruits for a long period of 8 months (May to December), some trees with a few fruits are found in other months also (Table 2).

The fruit abundance in this region from April to June appears to be a reciprocal adaptation with the breeding season of local birds. Most of the resident birds breed during this period (Yahya 1988) and thus the chances of seed dispersal are maximum.

Ficus trees provide the maximum quantity and variety of food to barbets. *Ficus tsiela* and *F. retusa* are more versatile and one or other of these species may be found fruiting throughout the year. However, no fruit was recorded on *F. retusa* in July-August. *Ficus mysorensis* and *F. insignis* were recorded fruiting during the rainy months, whereas *F. gibbosa* commonly fruits during drier months. *F. hispida* and *F. glomerata,* which were found fruiting invariably throughout the study area (the former at Thekkady and the latter at Lowercamp, Tamil Nadu) were never eaten by either species. At Sanjay Gandhi National Park, Mumbai *M. zeylanica*, were observed at times pecking at the ripe receptacles of *F. glomerata*, but never successfully, as the fruit fell down before the bird could pluck it. This could be due to the very weak peduncle of the ripe receptacle. However, near Churchgate, Mumbai, I found *M. haemacephala* pecking bit by bit on the semi-ripe receptacle of *F. glomerata,* but on no occasion did I find any barbet feeding on *F. hispida*).

Comparatively few species of trees fruit during February and March at Thekkady. This could be due to the deciduous nature of the dominant species. During this period, almost all the trees shed their leaves, the rain is comparatively meagre, and most of the trees prepare for the forthcoming fruiting season. According to Champion and Seth (1968) the seasonal distribution of rainfall has a far-reaching influence on the nature of vegetation.

Results and Discussion

The ratio of consumption of animal and plant matter by *M. viridis* and *M. rubricapilla* is almost similar in every month (Fig. 1 & 2), except during the nesting period (March-July) for *M. viridis* which then consumes a larger quantity of animal matter. This could be due to the marked difference between the nestlings' food in the two species (Yahya 1980, 1988).

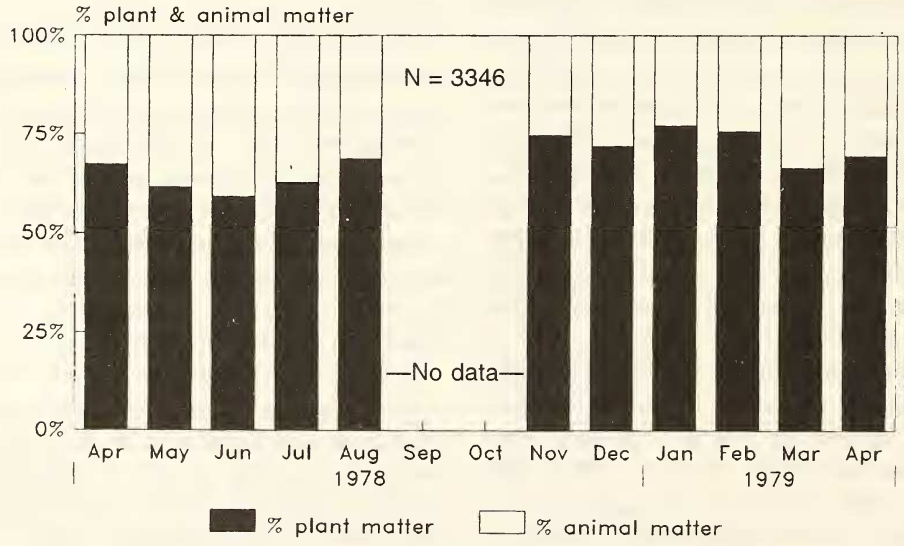


Fig. 1: Monthly feeding pattern of *M. viridis*

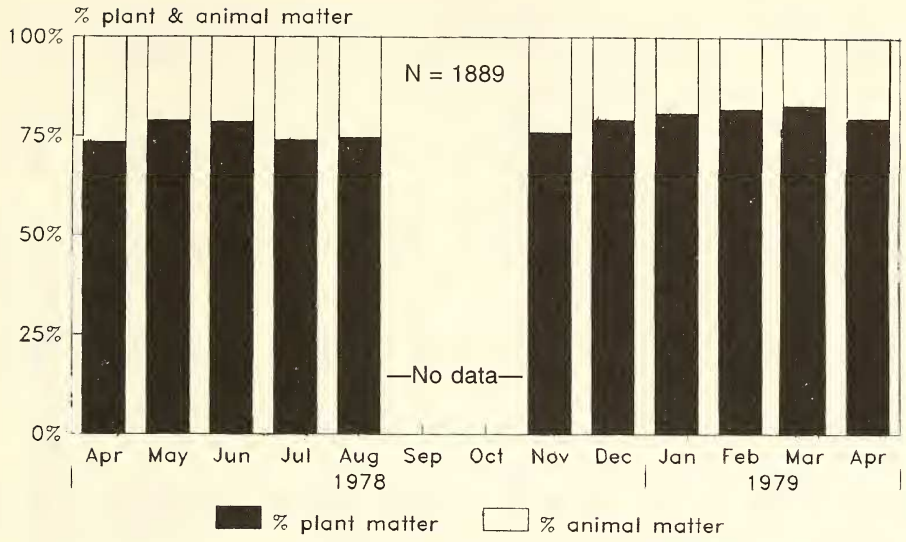


Fig. 2: Monthly feeding pattern of *M. rubricapilla*

Plant matter consumed by *M. rubricapilla* was restricted to fruits, and was about 8% more than that of *M. viridis*. However, the latter is a more versatile vegetarian, feeding on a wider range of vegetable matter. While *M. viridis* often feeds on the nectar of various flowers, *M. rubricapilla* was never found to do so.

Though predominantly frugivores, both *M. viridis* and *M. rubricapilla* also feed on a large amount of animal matter, the former consuming about 10% more than the latter (Table 3). Animal food items consumed by *M. viridis* were larger in size and more diverse than those of *M. rubricapilla*. *M. viridis* feeds on earthworms (seen only twice) butterflies, dragonflies, mantids, cicadas, beetles, spiders, termites and caterpillars, whereas *M. rubricapilla* restricts itself to smaller caterpillars, borer larvae, termites and ants. Though the food preferences of these congeneric species are distinguishable, their feeding niches and food often overlap.

Vegetable food of *M. viridis* and *M. rubricapilla*

As shown in Table 4, *M. viridis* and *M. rubricapilla* both show a preference for certain fruits in each month, but many fruits favoured by one species are frequently taken by the other also. Before analysing the data for a possible explanation of how these two congeneric sympatric species manage to coexist in the same habitat, a broad outline of their month-wise food items and preferences is given briefly.

During January-February when only a limited number of trees are fruiting, *M. viridis* very frequently forages on shrubs, while *M. rubricapilla* restricts itself to certain *Ficus* species. The common trees, on which the feeding of both species considerably overlaps during this period, are *Ficus mysorensis, F. retusa, F. gibbosa, F. infectoria* and *F. tsiela*. Among these, *M. rubricapilla* shows a much higher preference for *F. gibbosa, F. tsiala* and *F. retusa,*

TABLE 3
PERCENTAGE OF BARBETS FEEDING ON PLANT/ANIMAL MATTER

Species	No. of individuals	
	Fruit/nectar	Insects
M. viridis (n = 3346)	2352 – 70.29%	994 – 29.71%
M. rubricapilla (n = 1889)	1485 – 87.61%	404 – 21.39%

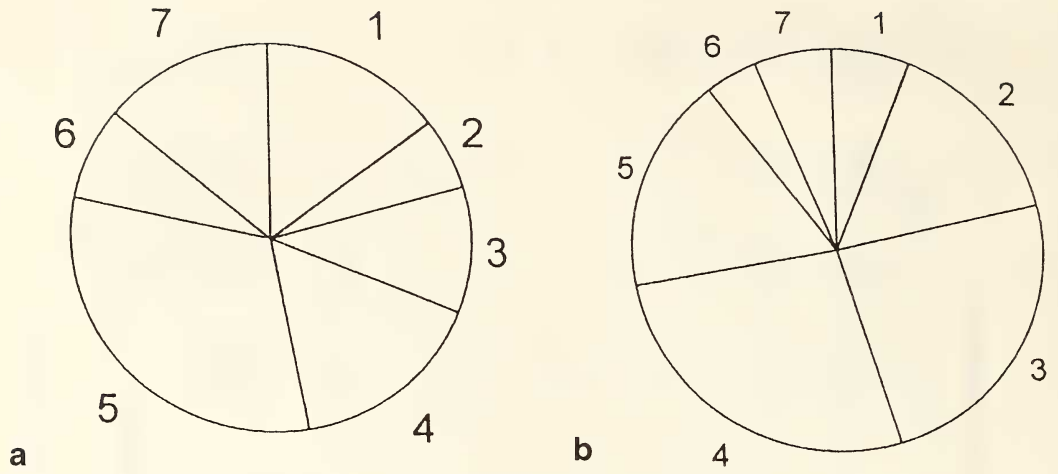
TABLE 4
*PERCENTAGE OF *M. VIRIDIS* AND *M. RUBRICAPILLA* FEEDING ON FRUITS/NECTAR

	1978							1979			
	Apr	May	Jun	Jul	Aug	Nov	Dec	Jan	Feb	Mar	Apr
Actinodaphne hookeri	13.88	12.97	9.77	7.62	-	-	-	-	-	-	-
	4.61	7.21	7.64	5.78	-	-	-	-	-	-	-
Bischofia javanica	-	-	-	-	-	-	3.30	4.70	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
Bridelia retusa	-	-	-	-	5.43	1.25	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
Bombax ceiba	-	-	-	-	-	0.62	3.37	12.82	2.36	-	-
	-	-	-	-	-	-	-	-	-	-	-
Careya arborea	2.44	-	-	-	-	-	-	-	-		-
	-	-	-	-	-	-	-	-	-	-	-
Erythrina sp.	-	-	-	-	1.81	3.95	2.86	0.85	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
Eucalyptus sp.	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	6.76	6.14	1.14	-	-			
Evodea lunuankenda	-	-	-	-	-	0.02	1.85	2.56	-	-	-
	-	-	-	-	-	0.85	0.83	1.48	-	-	-
Ficus gibbosa	6.12	-	-	-	-	2.08	3.03	-	6.73	-	-
	-	-	-	-	-	13.78	14.52	5.19	30.45	-	-
F. infectoria	-	-	-	-	-	2.08	23.91	2.56	-	-	-
	-	-	-	-	-	5.11	20.57	5.19	-	-	-
F. insignis	-	-	-	7.62	-	20.37	3.54	-	-	-	-
	-	-	-	5.14	-	11.65	2.13	-	-	-	-
F. mysorensis	-	-	5.54	4.57	9.05	1.25	3.87	10.26	11.44	1.54	-
	-	-	-	2.76	7.02	1.14	3.32	7.41	4.18	-	-
F. retusa	5.71	8.37	3.26	-	-	10.40	3.37	11.97	4.38	4.62	18.52
	18.44	38.46	23.57	-	19.23	22.16	12.81	28.89	23.58	20.31	39.77
F. tsiela	3.27	5.02	2.80	6.09	9.50	10.81	8.92	25.21	12.12	26.92	24.07
	11.06	14.42	23.92	35.13	21.93	20.17	24.90	32.60	22.40	62.50	39.77
Grewia tiliaefolia	-	7.95	30.94	25.91	28.96	-	-	-	-	-	-
	-	3.85	.25.22	24.16	20.18	-	-	-	-	-	-
Lantana camera	1.22	2.51	3.58	6.09	1.81	8.52	5.05	3.85	13.13	5.38	7.41
	-	-	-	-	-	-	-	-	-	-	-
Leea indica	-	2.93	2.80	7.62	9.50	11.43	5.05	-	0.67	-	-
	-	-	-	-	-	-	-	-	-	-	-

TABLE 4 (*contd.*)
*PERCENTAGE OF *M. VIRIDIS* AND *M. RUBRICAPILLA* FEEDING ON FRUITS/NECTAR

	1978							1979			
	Apr	May	Jun	Jul	Aug	Nov	Dec	Jan	Feb	Mar	Apr
Loranthus sp.	-	-	-	-	-	0.62	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
Machilus macrantha	5.71	-	-	-	-	-	-	-	16.16	16.15	10.00
	-	-	-	-	-	-	-	-	-	-	-
Macaranga sp.	-	3.77	-	-	-	1.25	-	-	2.36	-	-
	-	-	-	-	-	-	-	-	-	-	-
Olea dioica	6.53	2.09	-	-	-	-	-	-	-	-	2.59
	7.37	2.93	-	-	-	-	-	-	-	-	-
Santalum album	7.37	2.93	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
Scolopia crenata	5.71	-	-	-	-	-	-	-	-	-	3.33
	5.53	-	-	-	-	-	-	-	-	-	-
Solanum indicum	3.67	2.51	1.30	3.04	2.71	-	3.87	2.56	5.39	11.54	3.70
	-	-	-	-	-	-	-	-	-	-	-
Spathodea campanulata	-	-	1.30	1.83	0.09	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
Syzygium cumini	3.67	10.46	-	-	-	-	-	-	-	-	-
	3.23	5.29	-	-	-	-	-	-	-	-	-
Viscum sp.	-	-	-	-	-	-	-	-	1.01	-	-
	-	-	-	-	-	-	-	-	-	-	-
Ziziphus sp.	2.04	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-
Total feeding on	67.34	61.51	61.29	70.39	68.86	74.65	71.99	77.34	75.25	66.15	69.62
plant materials	73.28	78.85	80.35	79.73	74.50	76.00	79.08	80.76	81.82	82.81	79.54

*Notes: Upper figures in each column are for *M. viridis* and lower for *M. rubricapilla*.
Percentage is calculated from the total number of birds observed feeding both on animal and plant materials.
Remaining percentage is formed by birds feeding on animal matter.



1. *Actinodaphne hookeri*, 2. *Ficus gibbosa*, 3. *F. retusa*, 4. *F. tsiela*, 5. *Grewia tiliaefolia*, 6. *Ficus mysorensis*, 7. *F. insignis*.

Fig. 3: Percent difference in common fruits consumed by a: *M. viridis*, b: *M. rubricapilla*

whereas, both feed almost equally on *F. infectoria*. Comparatively, *M. viridis* prefers receptacles of *F. mysorensis*. In addition to feeding together with *M. rubricapilla* on *Ficus* trees, *M. viridis* frequently feeds on the fruits of *Bischofia javanica*, *Leea indica*, *Lantana camara* and *Solanum indicum*.

During March, *F. retusa* and *F. tsiela* are the main trees on which both species feed, *M. rubricapilla* far more than *M. viridis*. In April, several more species start fruiting. *M. viridis* shows a greater preference for *Actinodaphne hookeri* which fruits from April to July. In addition to berries of shrubs, *M. viridis* feeds exclusively on *Machilus macrantha*. *F. gibbosa* and *F. tsiela* fruit during April, for whose receptacles *M. rubricapilla* always shows greater preference (Fig. 3a & b).

From May to August, *Grewia tiliaefolia*, *F. retusa* and *F. tsiela* are the main fruiting trees on which both *M. viridis* and *M. rubricapilla* feed. During this period, both barbets show a higher preference for *Grewia* than for other fruits, though as usual *Ficus* trees are also visited freely and *M. rubricapilla* feeds more on *Ficus* receptacles than *M. viridis*. In addition, *M. viridis* also feeds on the fruits of *Macaranga*, *Lantana*, *Solanum* and on nectar of *Erythrina*; rarely also on nectar of *Spathodea campanulata*. The only fruits on which *M. rubricapilla* feeds exclusively are of *Eucalyptus*. During May to August, young fruits of *Eucalyptus* are quite often eaten by *M. rubricapilla*, mainly in the morning hours. *M. viridis* does not feed on Eucalyptus fruits, probably because this plant is recently (about 20 years earlier) introduced in the area. *M. viridis* shows higher preference for the fruits of *Olea dioica*, *Scolopia crenata* and *Syzygium cumini*, which appear from April to May. Sandalwood drupes are exclusively eaten by *M. viridis* during April-May.

During November-December *M. viridis* shows a higher preference for the figs of *F. insignis*, whereas *M. rubricapilla* feeds more frequently on *F. gibbosa*, *F. retusa* and *F. tsiela*; both show almost equal preference for *F. infectoria*. Only *M. viridis* feeds on fruits of *Solanum*, *Lantana* and *Leea indica*, and nectar of *Bombax ceiba* and *Erythrina*. Very rarely, both feed on *Evodea lunuankenda*, *Loranthus* and *Viscum* berries.

Therefore, although both the species

overlap on certain fruiting trees, almost every month *M. viridis* feeds exclusively on certain other fruits (such as *Bridelia retusa, Careya arborea, Lantana camara, Leea indica*), thus reducing the extent of food competition.

Possible reasons for food preference

The primary reason for food preference in *M. viridis* and *M. rubricapilla* appears to be the size of the fruit. However, selection of food may also depend on various other factors such as colour, taste, nutritive value, and even on smell, as suggested by several workers. Figs of *F. tsiela*, *F. retusa*, and *F. gibbosa* are preferred by *M. rubricapilla* and those of *F. mysorensis* and *F. insignis* by *M. viridis*. The figs of the former group are about one-fourth the size of the latter two. *M. rubricapilla* shows less preference for the fruits of *A. hookeri*, *G. tiliaefolia*, *Olea dioica*, *Scolopia crenata* and *Syzygium cumini*, which are larger than its favourite figs. The frequency of feeding in relation to fruit size is shown in Table 5. *M. rubricapilla* shows markedly higher preference for smaller fruits, though *M. viridis* also feeds on them.

Low preference for larger fruits by *M. rubricapilla* can be correlated with its smaller beak. Correlation between the size of the food and beak has also been reported in the Galapagos ground finches by Lack (1971), and in British finches by Newton (1967). Vijayan (1975) also found that the whitebrowed bulbul (*Pycnonotus luteolus*) with its slightly larger beak prefers bigger sized fruits than the coexisting redvented bulbul (*P. cafer*).

Though not analysed statistically, *M.*

TABLE 5
PERCENTAGE OF *M. VIRIDIS* AND *M. RUBRICAPILLA* FEEDING ON FRUITS OF DIFFERENT SIZE

	Average size of the fruit		
	<8 mm	8-16 mm	>16 mm
M. viridis (n = 2352)	37.45%	34.31%	28.24%
M. rubricapilla (n = 1485)	70.09%	19.90%	10.01%

zeylanica and *M. haemacephala* in Sanjay Gandhi National Park, Borivli, Mumbai (SGNP) and at Lowercamp, appeared to show remarkable food preference according to size; the former preferring figs of *F. bengalensis* and *F. mysorensis*, whereas the latter always congregated in greater numbers on *F. gibbosa*, *F. infectoria* and *F. religiosa*. *M. zeylanica* was often found sipping nectar on *Butea monosperma* at SGNP, but *M. haemacephala* was never seen doing so. At Ranikhet (Uttar Pradesh) *M. virens* was recorded gulping pear blossom (*Pyrus sinensis*) conveniently owing to its large beak.

Animal food of *M. viridis* and *M. rubricapilla*

Insects of different groups comprise the main animal food of *M. viridis* and *M. rubricapilla*. A month-wise record of animal food taken by these two species is shown in Tables 3 and 4 respectively. They usually hunt insects while following mixed hunting parties. However, during the breeding season both search for insects individually or in pairs. Quite often, both the barbet species were found capturing winged termites by short 'flycatching' sallies after light rain during March-April. These hunts normally take place in groups; one such group of 30 *M. rubricapilla* was recorded hunting winged termites for 30 minutes at Thanikuddy area. All the birds were perched on a *Terminalia paniculata* tree and caught the termites in the air one by one as they emerged from the ground. While the barbets were catching termites at about 16m height, swallows were also catching the termites much higher than the barbets, while red-whiskered bulbuls *Pycnonotus jocosus* were diving after them from bushes nearby.

During April-May the teak defoliator, *Hyblaea puera*, swarm on young teak leaves and both barbets congregate in large numbers to feed on these caterpillars along with other birds. Except for this caterpillar, no swarming of any particular species was noticed during the study period at Thekkady. A Phalangid species was

found swarming in hundreds on some shrubs and tree trunks throughout the year, but no bird was seen to feed on them.

Formation of Mixed Hunting Parties (MHP)

At Thekkady, the formation of large MHPs is a common avian activity. Generally bright hours of the day (Table 6) and comparatively open areas are selected for forming a MHP. In the non-breeding season, both *M. viridis* and *M. rubricapilla* commonly hunt with MHPs. A MHP sometimes follows a longer route, but normally limits itself to a circumference of *c.* 250 m or so. A 'wave of birds' as described by McClure (1972) was always noticed while observing the MHP. The difference between the flocks of insectivores and those assembled in a fruiting tree is that the insectivores' 'wave' moves through the forest, while the frugivores confine themselves to a specific tree (McClure, 1972).

TABLE 6
PERCENTAGE OF *M. VIRIDIS* AND *M. RUBRICAPILLA* FEEDING AT DIFFERENT HOURS OF THE DAY WITH MIXED HUNTING PARTY AVERAGE OF 11 MONTHS APRIL 1978 TO APRIL 1979

	6 to 10 hr.	10 to 14 hr.	14 to 18 hr.	Total No. of birds observed
M. viridis	09.75	75.00	15.25	682*/994**
M. rubricapilla	15.60	78.15	06.84	205*/404**

* Number of birds seen hunting with MHP

** Total number of birds seen feeding on animal mater

Position of barbets in MHP

Normally, 10-12 bird species comprise a single MHP, but sometimes as many as 25 species were recorded, the commonest and perhaps the 'nucleus' of the party being drongos. The common species forming a MHP were usually the racket-tailed drongo (*Dicrurus paradiseus*), grey drongo (*D. leucophaeus*), bronzed drongo (*D. aeneus*), goldenbacked woodpecker (*Dinopium benghalense*), goldenbacked threetoed woodpecker (*D. javanense*), common and southern tree pies (*Dendrocitta vagabunda, D. leucogastra*), common woodshrike (*Tephrodornis virgatus*), jungle and hill mynas (*Acridotheris fuscus, Gracula religiosa)* minivets (*Pericrocotus flammeus, P. cinnamomeus*), tits (*Parus major, P. xanthogenys*) velvet-fronted nuthach (*Sitta frontalis*) and various species of flycatchers. Barbets are opportunist members of the party, joining a passing MHP and hunting actively with the rest. *M. viridis* being far more active than *M. rubricapilla* exploits the maximum feeding zone.

While 'flowing' with the wave, *M. viridis* makes short sallies, glides down after insects or even lands on the ground, whereas *M. rubricapilla* never descends below the secondary level. However, both peck on dry and dead tree trunks like woodpeckers, and at times on dry leaves, and pick up caterpillars. Intraspecific aggression between *M. viridis* and *M. rubricapilla* was not as common in a MHP as noted on fruit trees. This could be due to the marked difference in their feeding zones and larger feeding areas. On a fruit tree, especially when fruit is scarce, there is more rivalry and aggression — fight and chase — while in a MHP the food resource is always scattered. However, intraspecific aggression among *M. viridis* itself is not uncommon.

Aggression among other groups of birds in a MHP is also not as common as among a feeding flock of frugivores in a fruiting tree. However, racket-tailed drongos always try to dominate and chase other birds, even snatching morsels from them, as I have witnessed on several occasions.

COMPETITION FOR FOOD AND COEXISTENCE

From the foregoing account, it appears that *M. viridis* and *M. rubricapilla* do not compete severely for food. However, they do overlap on certain fruiting trees or when hunting in a mixed hunting party of insectivores. As discussed below,

the food competition is further reduced owing to their different feeding behaviour and overall dimensions.

Feeding habitat

Utilisation of different parts of the vegetation differs greatly between *M. viridis* and *M. rubricapilla*. The feeding zone is clearly distinguishable when both feed in a single microhabitat. During the study period, whether feeding on fruit or hunting insects, individually or with MHP, 82% *M. rubricapilla* were recorded feeding on the tertiary level, whereas only 51% *M. viridis* fed at that level. *M. rubricapilla* was seldom recorded descending below the secondary level (Table 7), while *M. viridis* frequently fed at the primary level or at times even on the ground, *M. rubricapilla* never does so.

TABLE 7
PERCENTAGE OF *M. VIRIDIS* AND *M. RUBRICAPILLA* FEEDING AT DIFFERENT LEVELS

	M. viridis (n = 3346)	*M. rubricapilla* (n = 1889)
Ground	0.15%	-
Primary level, 1 to 4 m	18.42%	-
Secondary level, 4 to 8m	29.93%	17.06%
Tertiary level, above 8m	51.50%	82.94%

Ecological isolation by feeding heights has been reported in English titmice *Parus major* by Hartley (1953) and Gibb (1954). Vijayan (1975) suggested that the difference in the feeding zone is distinguishable in coexisting *Pycnonotus cafer* and *P. luteolus* at Point Calimere (Tamil Nadu) and plays a major role in isolating them ecologically.

At Lowercamp, *M. zeylanica*, *M. viridis* and *M. haemacephala* were sometimes observed hunting together with a MHP. On those occasions, the feeding zones of the three species were always markedly different; *M. zeylanica* hunted at the topmost level, *M. haemacephala* mostly at secondary level, whereas *M. viridis* fed at the primary and secondary levels.

Method of feeding

The feeding methods of *M. viridis* and *M. rubricapilla* differ considerably, especially on larger fruits like the receptacles of *Ficus mysorensis* and *F. bengalensis* and other similar sized fruits. While *M. viridis* swallows the entire fruit, *M. rubricapilla* feeds by pecking and eating it bit by bit. The difference in feeding method is obviously due to the differences in their beak size. While *M. viridis* swallows larger fruits easily, *M. rubricapilla* cannot do so, and has to spend more time and energy on the same fruit. At Lowercamp, occasionally *M. zeylanica*, *M. viridis*, *M. haemacephala* and sometimes *M. rubricapilla*, were recorded feeding together on *F. bengalensis* and *F. mysorensis*. The feeding method of the two larger and two smaller 'pairs' was noted to be different: *M. zeylanica* and *M. viridis* with larger beaks normally swallowed the entire receptacles, whereas the other two (with almost equal beak size) fed by pecking at them bit by bit. Such a difference in method of feeding was recorded in unequal sized congeneric sympatric *M. asiatica* and *M. haemacephala*, and *M. lineata* and *M. haemacephala* respectively in Calcutta Botanical Garden and in Valmiki Tiger Reserve (Bihar).

Even while hunting insects individually or with MHP, *M. viridis* frequently catches cicadas, butterflies and such larger insects, whereas *M. rubricapilla* restricts itself to ants, small flies and termites.

Feeding cycle

Barbets are voracious feeders and can be seen feeding throughout the day. However, intensity of feeding activity varies during different hours of the day (Table 8). Both *M. viridis* and *M. rubricapilla* show maximum feeding activity during morning hours. *M. viridis* is comparatively less active around noon and more active in the afternoon. The difference in feeding cycle appears to be due to the differences in their roosting hours (Yahya 1987). On an

average, *M. rubricapilla* roosts one hour longer than *M. viridis*, and hence is probably more active in the noon hours also, while *M. viridis* takes rest. After some rest *M. viridis* becomes more active and hence spends more time in feeding, while in the later afternoon *M. rubricapilla* spends more time in preparing to roost.

TABLE 8
PERCENTAGE OF *M. VIRIDIS* AND *M. RUBRICAPILLA* FEEDING AT DIFFERENT HOURS OF THE DAY ON DIFFERENT FRUIT TREES

	6 to 10 hrs	10 to 14 hrs	14 to 18 hrs
M. viridis (n = 2325)	47.40	22.50	30.09
M. rubricapilla (n = 1485)	48.00	28.33	23.67

Similar results were obtained while observing *M. zeylanica* and *M. haemacephala* at Sanjay Gandhi National Park. *M. zeylanica* showed less feeding activity during noon hours whereas *M. haemacephala* was quite active during that period. *M. haemacephala* also roosts almost one hour longer than *M. zeylanica* (Yahya 1987). Skutch (1944) also found the prong-billed barbet most active in the morning hours and least active at noon, when it rested for 1 to 2 hours.

Aggression at feeding sites

Intraspecific aggression is much more pronounced in *M. viridis* than in *M. rubricapilla*. The former is far more aggressive towards other species of birds as well. While feeding with frugivorous flocks, *M. viridis* chases almost all birds except the koel *Eudynamys scolopacea*. The koel was found to be the most dominant species and no other bird dared to fight it back. Intraspecific aggression at feeding sites might play some role in isolating two congeneric sympatric species and thus help in successful coexistence. Grubh (1979) concludes that intraspecific aggression at food plays an important role in successful coexistence of the Eurasian griffon *Gyps fulvus*, whitebacked vulture *G. bengalensis* and longbilled vulture *G. indicus* in Gir Forest: while the whitebacked is comparatively peaceful at feeding sites, the other two spend considerable time quarrelling with their own kind, thereby indirectly permitting the weaker whitebacked to feed.

Morphological adaptations for feeding

In physical dimensions *M. viridis* and *M. rubricapilla* are different. The larger beak of *viridis* enables it to swallow larger fruits and insects, which *rubricapilla* cannot do. This could help them in reducing food competition and successful coexistence. Zacharias (1978) states that owing to the difference in overall size, the larger jungle babbler *Turdoides striatus* mostly feeds on larger insects while hunting together with whiteheaded babblers *T. affinis*. Another point which supports the view that the overall size difference in barbets may play an important role in their successful coexistence is the common occurrence side by side of two species of different sizes. During my study I found *M. viridis* and *M. rubricapilla* occurring together at Thekkady; *M. zeylanica* and *M. haemacephala* coexisting at Sanjay Gandhi National Park, Hazaribagh National Park and at the Betla Tiger Reserve; *M. lineata* and *M. haemacephala* coexisting in Valmiki Tiger Reserve and Corbett National Park, and *M. asiatica* and *M. haemacephala* in Calcutta City. All these coexisting congeneric species have the same remarkable differences in size. Hinde (1959) suggested that the morphological differences between coexisting species are not merely adapted to feeding methods, but largely determine them. The degree of dominance while feeding may also vary according to the body size as reported by Grubh (1979) among different species of griffon vultures – the largest (Eurasian griffon) was found to be the most dominant and the smallest (whitebacked) the least.

CONCLUSION

Though fruits of different species of plants constitute the main food of barbets, both *M. viridis* and *M. rubricapilla* feed on insects to

a considerable extent. The former consumes about 30% animal matter, whereas the latter consumes about 20%. *M. viridis* consumes more insects during the breeding season than *M. rubricapilla*. Only *M. viridis* sips nectar from flowers. Both species often hunt together with mixed hunting parties of insectivores; *M. viridis* always joins the party in larger numbers and for longer periods. During March-April, after light showers, both the species hunt winged termites in groups; sometimes this single-species group may consist of as many as 30 individuals.

Food competition between the coexisting *M. viridis* and *M. rubricapilla* is not severe, for they normally procure food from different feeding zones. Intraspecific aggression among *M. viridis* is markedly more while feeding either on a fruit tree or with a mixed hunting party of insectivores which reduces its competition for food with *M. rubricapilla* to some extent. Another factor responsible for ecological isolation in feeding behaviour is the varying heights from which they exploit food: while *M. viridis* feeds at primary, secondary and tertiary levels, and at times lands even on the ground, *M. rubricapilla* restricts itself to the secondary and tertiary levels.

The study also supports Huxley's (1942) postulation that "big size difference between congeneric species of birds are means of ecological isolation". Based on the data collected in the present study, it could be added that since food is the primary requirement of an animal, for the successful coexistence of two closely related species in a single habitat, divergent morphological adaptations in relation to feeding habits are an outcome of the process of natural selection.

Barbets are economically important and play a significant role in controlling various harmful insects, in cross-pollination and seed dispersal of trees. Though they are presently common in many places, their conservation priorities should be anticipated by wildlife biologists and managers to maintain sustainable populations of different species.

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